AXIALLY LOADED OF COLD-FORMED STEEL SECTION WITH OPENING

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SUPERVISOR'S DECLARATION

I hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor in Civil Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Unsur struktur keluli yang terbentuk sejuk telah digunakan secara meluas dalam industri pembinaan dan telah muncul sebagai penyelesaian ekonomi pilihan untuk bangunan komersial dan perindustrian satu tingkat. Bahagian terbina dalam keluli terbentuk sejuk biasanya digunakan sebagai unsur mampatan untuk membawa beban yang lebih besar apabila seksyen tunggal tidak mencukupi. Walau bagaimanapun, bahagian yang dibina menunjukkan beberapa tingkah laku yang unik yang kod-kod semasa tidak mempunyai peruntukan yang komprehensif. Ini adalah samar-samar kerana tingkah laku keluli bergulung panas berbeza daripada keluli terbentuk sejuk. Penyelidikan ini akan menumpukan pada bahagian terbina terbuka atau bahagian I. Ahli struktur keluli terbentuk sejuk biasanya datang dengan kehadiran perforasi. Tebukan adalah lubang atau pembukaan yang dibuat pada keluli terbentuk sejuk untuk memudahkan kerja pembinaan. Ia biasanya dilengkapi dengan bentuk dan saiz yang berbeza berdasarkan fungsinya seperti menampung elektrik, paip dan penghawa dingin atau perkhidmatan pemanasan. Di samping itu, sangat sedikit kajian telah dijalankan untuk mengkaji bahagian terbina keluli terbentuk sejuk seperti back-to- lajur C-channel belakang tanpa jurang, lajur C-saluran belakang dengan lajur jurang, battened, dan berlapis. Oleh itu, matlamat penyelidikan ini adalah untuk menentukan beban utama keluli terbentuk sejuk dengan dan tanpa membuka melalui kajian eksperimen. Sejumlah 8 sampel diuji dalam eksperimen ini. Setiap sampel mempunyai ketebalan nominal 1.2 mm dan panjang lajur 600 mm yang sama, tetapi jenis seksyen yang berlainan yang merupakan seksyen tunggal dan seksyen terbina, dan diameter panjang web yang berbeza iaitu 103 mm dan 203 mm. dimampatkan di antara hujung yang disokong hanya pada kedua-dua hujungnya. Hasil percubaan ini menunjukkan bahawa beban muktamad setiap sampel sangat berbeza pada kedudukan perforasi dan panjang web. Hasilnya dibentangkan dalam tiga bahagian yang merupakan beban berbanding anjakan menegak, beban vs. anjakan melintang dan tingkah laku tenggelam.

ABSTRACT

Cold-formed steel structural elements have been widely used in the construction industry and have emerged as a preferred economical solution for single-storey commercial and industrial buildings. Cold formed steel built-up sections are commonly used as compression elements to carry larger loads when a single section is insufficient. However, the built-up sections exhibit some unique buckling behaviors which the current codes do not have comprehensive provisions. This is ambiguous as the behavior of hot rolled steel is different from cold formed steel. This research will be concentrating on open built-up section or I-section. Structural members of cold-formed steel usually come with the presence of perforations. Perforations is a hole or opening that are made on the cold-formed steel to ease construction work. It usually provided with different shapes and size based on its function such as to accommodate electrical, plumbing and air conditioner or heating services In addition, very few studies have been carried out to study cold formed steel built-up sections such as back-to-back C-channel column without a gap, back-to-back C-channel column with a gap, battened, and laced columns. Thus, the aim of this research is to determine the ultimate load of cold-formed steel with and without opening through experimental studies. A total of 8 samples were tested in this experiment. Each sample has a nominal thickness of 1.2 mm and the same length of 600 mm columns, but different types of sections that are single sections and built-in sections, and diameters of web lengths of 103 mm and 203 mm. compressed between the supported end only at both ends. The result of this experiment shows that the ultimate load of each sample varies greatly on the perforation position and the web length. The result is presented in three section which are load vs. vertical displacement, load vs. horizontal displacement and buckling behavior.

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LIST OF SYMBOLS

LIST OF ABBREVIATIONS

BS	British Standard
CFS	Cold-Formed Steel
DBB	Distortional buckling at bottom support (back)
DBF	Distortional buckling at bottom support (front)
DMF	Distortional buckling at middle span (front)
DTB	Distortional buckling at top support (back)
DTF	Distortional buckling at top support (front)
FE	Finite Element
FKASA	Fakulti Kejuruteraan Awam dan Sumber Alam
LBF	Lateral Buckling
LGD	Local Distortional Global
LVDT	Linear Vertical Displacement Transducer
WBF	Warping buckling at bottom support (front)
WMB	Warping buckling at middle span (back)
WMF	Warping buckling at middle span (front)
WTB	Warping buckling at top support (back)

CHAPTER 1

INTRODUCTION

1.1 Introduction

In steel structures, there are two types of structural steel members which the hot-rolled and cold-formed steel. The hot-rolled steel members always preferred as the popular choice of steel group and are widely used in construction industry but because of the several advantages of cold-formed over the hot-rolled steel sections, the use of cold-formed high strength steel structural members shown a rapid increase. Cold-formed steel (CFS) structural members are commonly provided with holes to accommodate electrical and plumbing of building. CFS members as shown in Figure 1.1 is formed in room temperature state and the steel product is formed by a steel strip or sheet of uniform thickness that combined together to formed a structure. The use of CFS section in others country can be found in rail transport, building and bridge construction and various type of equipment. In Malaysia, the common used of CFS are limited to a roof truss and framing.

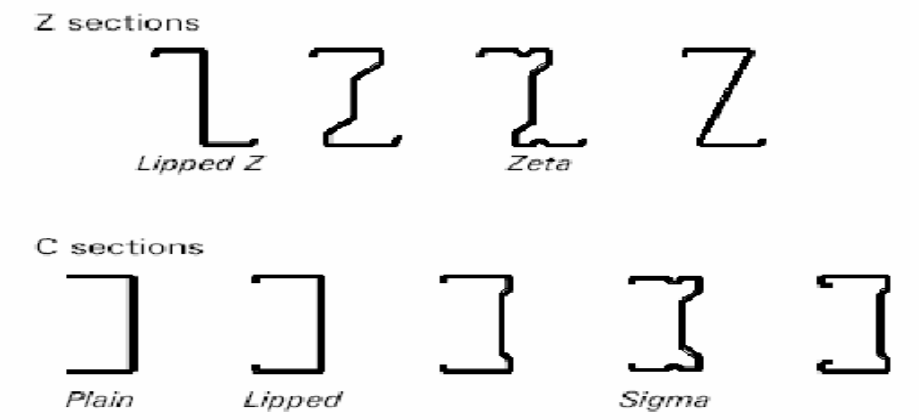

Figure 1.1 Cold-formed steel members

Source : (Crisan, et al., 2012)

CFS products are shaped from steel sheet, strip plate or flat bars by cold rolling-forming method or press braking method. They can be produced in large quantity in a limited time consumption and at high speed with consistent quality. The thickness of material formed together usually range in general between 0.70 mm to 3.5 mm. The critical elastic buckling loads are associated with local, distortional, and global buckling. Unlike heavy hot-rolled steel sections, cold-formed thin-walled sections tend to buckle locally at stress levels lower than the yield strength of the material when they are subjected to various loading conditions. However, failure modes are not commonly encountered in normal structural steel design specifications, and therefore, extensive testing is required to provide a guideline for the design of cold- formed thin-walled structural members.

The use of cold formed steel (CFS) structures in residential construction has become increasingly popular all over the world in recent decades and is now a highly competitive alternative to traditional structural systems. The increase in the CFS construction is due to the ongoing development and improvements in the field, the consequential availability of more cost-effective solutions and the broad recognition of the advantages of CFS framing (Figure 1.2). Some of the widely acknowledged advantages of CFS framing are lighter weight, reduces transport and handling costs, and ease of prefabrication and mass production.

Figure 1.2 Uses of CFS framing

Source : (Dinis, et al., 2012)

Opening in CFS sections made specifically for fasteners such as bolts, screws, etc., may be neglected as openings are filled with material (Figure 1.3). However, for any other opening, the reduction in cross sectional area caused by these opening should be taken into account. The ultimate strength and elastic stiffness of a structural member can vary with opening, size, and shape. In evaluation of the section properties of members in compression, openings need to be considered. The perforations can be divided by pre-punched or punched-on-site but mostly pre-punched are more favourable due to the problem that will rise later if the hole are not accurately made.

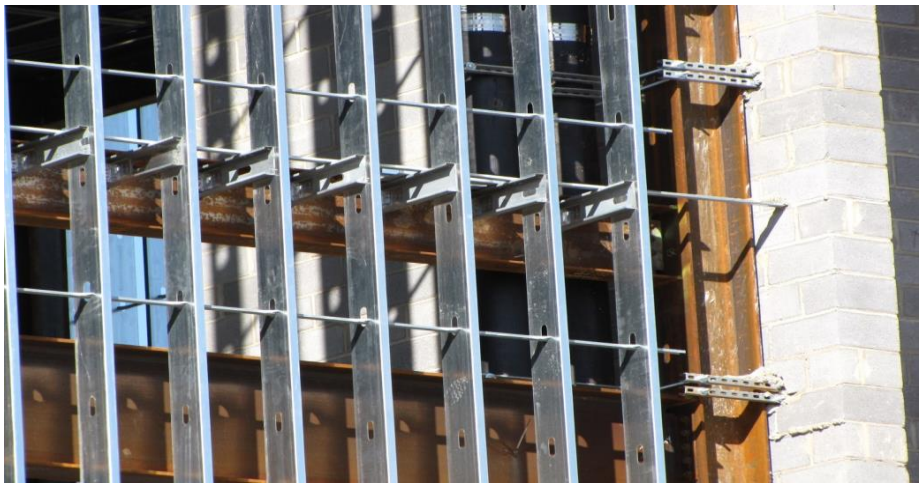

Figure 1.3 Cold-formed steel with openings

Source : (Dinis, et al., 2012)

1.2 Problem Statement

CFS structural members are commonly manufactured with holes such as joist/beams, for piping, electrical-wiring, plumbing, and bracing. Typically, it is manufactured with different shapes, and sizes. In particularly, large openings on the web are preferred by the contractors as the mechanical and electrical works become more and more complex in today's building industry. Besides, it's also facilitate various services in building construction. Due to the variety of size, and shapes, some task of research to provide the practical design need to be done where the strength is likely reduced by the existence of the perforation. Many problems had risen due to the existing of opening because the design process will be much more complicated and need extra study from the expert and already lead to the collapse of the building. This lead to the usage of the cold-

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